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THESIS

AN EVALUATION OF A RASTER SCAN DISPLAY FOR USE IN AN AIRCRAFT INFORMATION HANDLING SYSTEM

by

Walton Lewis Hogan, Jr.

March 1977

Thesis Advisor: G. M. Raetz

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) An Evaluation of a Raster Scan Display for Use in an Aircraft Information Handling System		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; March 1977
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Walton Lewis Hogan, Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE March 1977
		13. NUMBER OF PAGES 98
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Postgraduate School Monterey, California		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

computer graphics
aircraft spotting
interactive terminal
raster scan display

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The work described herein was part of continuing research in the area of computer aided information management and display as applied to air operations on an aircraft carrier. The purpose of this study was to evaluate the Hughes CONOGRAPHIC-12 Graphics Display Terminal in a computer graphics-aided aircraft information handling system. The approach taken in this study was to implement a realistic aircraft information handling system on a

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
(Page 1) S/N 0102-014-6601

20. (cont.)

Digital Equipment Corporation PDP-11/50 minicomputer within the conventions of the C programming language and the UNIX operating system at the Naval Postgraduate School Computer Laboratory.

The study includes a description of previous efforts in the area, a description of the CONOGRAPHIC-12 hardware and the software written to evaluate the display terminal. The study also includes an evaluation of the CONOGRAPHIC-12 display terminal as both a dynamic interactive display terminal and a repeater-only terminal at six representative stations.

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An Evaluation of a
Raster Scan Display
for Use in an
Aircraft Information Handling System

by

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Lieutenant, United States Navy
B.S., United States Naval Academy, 1968

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE

from the

NAVAL POSTGRADUATE SCHOOL
MARCH 1977

Thesis
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ABSTRACT

The work described herein was part of continuing research in the area of computer aided information management and display as applied to air operations on an aircraft carrier. The purpose of this study was to evaluate the Hughes CONOGRAPHIC-12 Graphics Display Terminal in a computer graphics-aided aircraft information handling system. The approach taken in this study was to implement a realistic aircraft information handling system on a Digital Equipment Corporation PDP-11/50 minicomputer within the conventions of the C programming language and the UNIX operating system at the Naval Postgraduate School Computer Laboratory.

The study includes a description of previous efforts in the area, a description of the CONOGRAPHIC-12 hardware and the software written to evaluate the display terminal. The study also includes an evaluation of the CONOGRAPHIC-12 display terminal as both a dynamic interactive display terminal and a repeater-only terminal at six representative stations.

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ACKNOWLEDGEMENTS

I wish to express my deep appreciation to my thesis advisor, Gary M. Raetz, for his guidance and patience. His knowledge and assistance have been invaluable in evaluating the CONOGRAPHIC-12 graphic display terminal for use in an aircraft information handling system.

I also wish to thank my wife Carol for her love, support and self-sacrifice. Her faith in me gave me strength when I most needed it.

I. INTRODUCTION

The purpose of this study was to provide an evaluation of a raster scan graphics display terminal, the Hughes CONOGRAPHIC-12, in a computer graphics-aided aircraft information handling system for use onboard a modern aircraft carrier. The primary method presently in use for information transmittal and display provided the impetus to investigate other means to assist the Aircraft Handling Officer (ACHO) and other related personnel in coordination of air operations.

An interactive graphics system was proposed and simulated by Johnson and Woolley [7]. The simulation of the system utilized two identical ADAGE AGT-10 graphics computers interfaced with a XEROX XDS 9300. This system used a graphics terminal that required continual refresh data from the host computer. The refresh requirement meant that the host computer spent a large amount of time transmitting essentially the same data for the picture to remain visible to the user. This requirement either limited the amount of data that could be displayed because of the time required for the refresh cycle, or required the system to have much more complex, and therefore expensive, graphics terminals.

The favorable reception given the Johnson and Woolley simulation effort led to a continued program at the Naval Postgraduate School to evaluate specific hardware required to implement a similiar system. Some of the specific evaluation criteria which a display terminal would have to meet include smaller physical size and lower initial and maintenance costs. Specific requirements for each station and a determination of what special features were desirable for each station would have to also be considered. The criteria which Johnson and Woolley established regarding display format and information content were considered the minimum which must be met in any subsequent implementation.

A minicomputer, such as the AN/UYK-20, controlling a small general purpose display terminal appeared to meet the general criteria for a host processor [12]. Since an AN/UYK-20 computer was not available to control the CONOGRAPHIC-12 terminal in this study, a PDP-11/50 minicomputer was substituted in its place [2]. This substitution introduced the necessity of determining the capabilities of the processor and peripherial equipment necessary for the implementation, in addition to the evaluation of the terminal itself.

The specific goal in this evaluation was to determine the suitability of the CONOGRAPHIC-12 terminal in the aircraft information handling system. At the time this work was completed, efforts were currently underway at Naval Weapons Center, China Lake, California, to determine the

specific requirements for the actual system to be implemented onboard an aircraft carrier [3].

This thesis evaluated and compared the CONOGRAPHIC-12 terminal with the Johnson and Woolley simulation system at the Naval Postgraduate School. It would be extremely significant if the CONOGRAPHIC-12 Graphic Display Terminal could duplicate the information content and ease of interaction of the refresh display system. The CONOGRAPHIC-12 display terminal was much less expensive than a refresh device, and did not require constant refresh from the host processor. Both of these facts were important in any consideration of a display terminal for an actual implementation.

II. BACKGROUND

As indicated previously, the primary method for information transmission and display used onboard modern aircraft carriers for the control of aircraft on the flight and hangar decks provided the major impetus to search for an alternate method. Previous studies and research, beginning with the 1966 CADOCS study, had determined that the management and control of aircraft was needlessly complicated by inadequate communication and information handling, and had proposed a computer-aided graphics system as a possible alternative to the present system [7].

Presently, aircraft location decisions are made by the Aircraft Handling Officer (ACHO) based on information kept on plexiglass boards and status boards. The boards contain the information needed for moving and spotting aircraft. The boards are updated by information received by sound powered phones, telephones, messengers and verbal communication via 5-MC circuits with Squadron Maintenance Chiefs. With this information, and the information contained on mockups of the flight deck and hangar deck, i.e., location, orientation, status and side number of each aircraft, the ACHO makes the spotting decisions.

An attempt to provide a display medium which would decrease the number of locations of information required for

the spotting decision, and also provide a more accurate data base, lead to the Johnson and Woolley simulation effort. The Johnson and Woolley system was implemented in a research environment on equipment that is not suitable for implementation on an aircraft carrier. However, the simulation demonstrated the feasibility of the concept and demonstrated that the concept was both functional and a viable alternative to the present system.

The decision to incorporate display terminals with local processing power was originally made based on the refresh requirements of the cathode ray tube used in the original simulation. The refresh requirements could be met by the host computer, but would be costly because of the large amount of host processor time involved. Addition of several such stations would degrade the interaction rate to an unacceptable point. This could be overcome by larger machines, but the disadvantage with this approach was both the associated increase in cost per terminal and the increase in space requirements.

The desire to implement the system on a minicomputer without the requirement for excessive memory dictated that refresh requirements of the display be minimized. This requirement directed investigation of storage tube type displays. At the present time, storage tube displays do not have a requirement for continual refresh from the host computer.

The development of storage tube displays provided a partial solution to the refresh requirement problem. This type of display avoided the need for a display buffer and display refresh. Once the image was written on the video memory, it did not need to be refreshed since it was electronically stored on the target of the storage tube. One potential disadvantage, however, was that the image on the storage tube was static, making dynamic interaction difficult.

In this thesis, the term static is used to mean that the image may not be modified without erasing and redrawing the entire image. The CONOGRAPIC-12 display terminal used in this evaluation is a variation of the storage tube display. This CONOGRAPHIC-12 has the unique capability of selective erasure, a capability discussed more fully in the hardware section of this thesis. Of primary interest in the evaluation of the CONOGRAPHIC-12 display terminal was the effect of an essentially static display in a dynamic application. Other items of interest also included drawing speeds, host computer requirements, response to user commands and features available on this display which were not available in previous implementations. These features included hardware options such as hardcopy and local terminal memory.

III. HARDWARE DESCRIPTION

In this section a description of the hardware components required to simulate the aircraft information handling system as it was implemented in this evaluation is presented.

A. HOST COMPUTER, DEC PDP-11/50

The host computer system utilized in this implementation consisted of one Digital Equipment Corporation (DEC) PDP-11/50 processor, a Datamedia 2500 alphanumeric terminal and the CONOGRAPHIC-12 graphics display terminal. The PDP-11/50 processor operated with the UNIX operating system which was developed at Bell Telephone Laboratories, Inc. [10].

The minimum hardware configuration required for the implementation of this simulation consisted of the following:

1. A minicomputer having capabilities similiar to the PDP-11/50.
2. Approximately 48K of memory available to the user. The evaluation program needed about 27K, but was written to support six separate display stations and was larger that would be necessary in an actual implementation. The data base required about 19K, and was designed to support a maximum of 144 aircraft.
3. The CONOGRAPHIC-12 display terminal.

The present implementation of the simulation also used a Vector General Tablet as a locator or coordinate input device [4]. This was done because the software support for the joystick/cursor capability of the CONOGRAPHIC-12 was not implemented. Use of the tablet had no effect on the simulation, but made aircraft input location on the deck somewhat awkward since the user had to look at the tablet instead of using a cursor on the screen.

B. CONOGRAPHIC-12 DISPLAY TERMINAL

The CONOGRAPHIC-12 Interactive Graphic Display System included a raster scan CRT display, alphanumeric keyboard, program function keyboard, joystick, extended symbol capability, hardware zoom, and selective erasure.

A simplified functional view of the CONOGRAPHIC-12 display system as presently implemented at the Naval Postgraduate School is depicted in Figure 1.

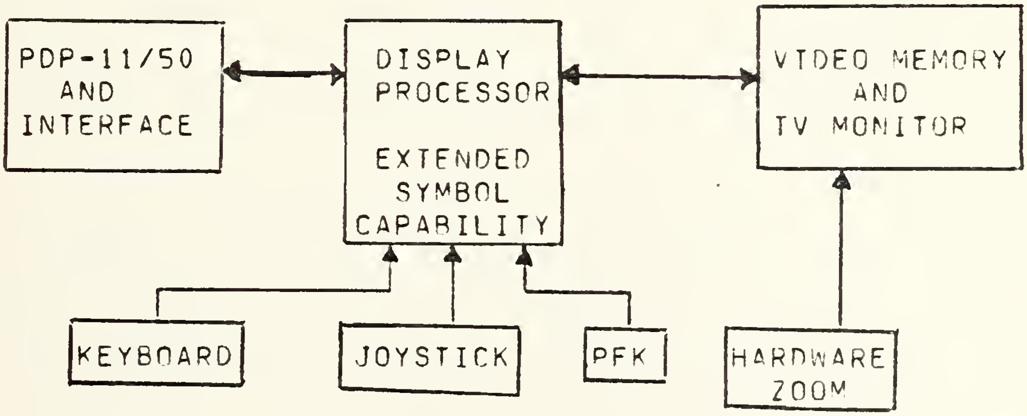


FIGURE 1

The video memory utilized in this system is a Hughes type H-129A Scan Converter Tube [6]. This scan converter tube is similiar to a standard Cathode Ray Tube (CRT) and consists of an electron gun, appropriate focusing and deflection mechanisms and a storage target. The image to be stored on this tube is described by digital X-Y coordinates and transmitted by the host computer to the display processor. This data will cause the appropriate beam deflections over a square inscribed on the storage tube. The stored information is then read by a scan converter and a copy is displayed on the high resolution television monitor. Once written, the display remains visible until erased, relieving the host computer of the necessity to continually regenerate the output data or refresh the display.

The program function keyboard (PFK) in the current implementation consisted of thirty-two function keys which produced codes which were programmatically interrogated by the host computer. Each terminal could also support up to four program function keyboards as input devices.

The alphanumeric keyboard in the current implementation can be programmatically enabled and disabled. When enabled, striking a key generates an interrupt at the host processor and the keycode is subsequently read by the host processor. In local mode, the alphanumerics are displayed on the screen, but do not generate an interrupt to the host computer.

Another feature of the present CONOGRAPHIC-12 terminal that is useful is the movable cursor that can be programmatically enabled. The cursor may be used as a locator device by programmatically reading the graphics display terminal's registers which contain the X-Y coordinates of the cursor crosshair center. The cursor is a full screen crosshair which provides accurate location information.

The hardware zoom feature of the current implementation is independent of a user program. Three controls are available to the user which do not effect the actual image stored on the video memory target. The three controls are an on/off switch to activate or deactivate the zoom feature, a joystick for image positioning and a gain control to change magnification up to six diameters. The copy on the monitor screen is varied by the use of the three controls and allows the user a convenient method of examining details which may be difficult to distinguish in the normal mode. Currently, the zoom mode does not modify the stored image. This capability was considered a significant advantage, since the user could examine a portion of a display from a much greater distance from the screen. The hardware zoom also allowed a user the ability the filter out unwanted or unneeded information.

A significant characteristic of the present terminal is the capability to perform selective erasure. This capability allows part of the displayed image to be removed

without affecting the rest of the image. At the present time, the hardware mechanism to accomplish selective erasure entails redrawing the image to be erased in the erase mode. If the subpicture being erased overlayed another subpicture, the erasure would cause the remaining subpicture to have a gap in it, which would then require a redraw. However, only the affected subpicture would have to be redrawn. Presently, this feature relieves the host computer from having to refresh the entire display because of some small change in the image.

The CONOGRAPHIC-12 display terminal at the Naval Postgraduate School has another significant hardware feature that was evaluated. The present display has the capability of either displaying an image in a black on white mode, or in a white on black mode. This hardware selection feature allows a user to select the most suitable image presentation. Since a hardware switch performs the display change, no demand is placed on the host computer to modify any commands to the terminal.

Another feature which the CONOGRAPHIC-12 presently supports is an ability to interface to a device for hardcopy output. This feature was not avaliable on the CONOGRAPHIC-12 at the Naval Postgraduate School, but was considered to be an important feature desirable to have in any display terminal used in an aircraft information handling system.

The Arithmetic Processor Extension as currently implemented on the CONOGRAPHIC-12 display terminal is a special extension to the display processor which is used in special operations such as picture offsetting, scaling and rotation or reflection operations. At the present time, this ability relieves the host computer of the calculations necessary to perform these functions. This means that the host spends significantly less time in display list manipulation and reduces the amount of data that must be transmitted to the display processor. At this time, the basic Arithmetic Processor on the CONOGRAPHIC-12 keeps track of the drawing position on the screen and exercises control over intensity variation and the dot/dash line capability.

The Extended Symbol Option of the CONOGRAPHIC-12 as it is currently implemented at the Naval Postgraduate School is significant. This option uses the available memory in the CONOGRAPHIC-12 to store predefined fonts. The host processor then causes the display processor to draw the symbol stored in its memory at the given address without needing any more data from the host.

The Extended Symbol Option allows the user the ability to switch the display from one related set of symbol subroutine, called a font, to another. The fonts are contained in Read-Only-Memory (ROM). The Symbol Subroutine Controller option is an enhancement of the present extended symbol option which allows a user to construct symbol sets for storage in Read-write Memory (RAM). Although the design

and explanation of these options seemed to be directed toward character sets, the observed fact was that any graphic subprogram could be loaded into memory and subsequently executed by the display processor on command from the host processor. This meant that static images such as an aircraft carrier deck outline or station view selection pages could be stored in the display terminal's local memory.

When the CONOGRAPHIC-12 display was placed in the symbol mode, drawing on the screen was accomplished when the host processor sent the base address of the font, and an eight bit byte which referenced the subroutine. The byte was used as an offset from the font base address. The display processor extracted the command from that memory location, which was a jump to a subroutine command, and then jumped to the subroutine, drew the image and returned. Commands in local memory were acted on as though the host processor had sent them.

The significance of the extended symbol option and the symbol subroutine option was the effect on the data transmission requirements necessary from the host computer to the display terminal. The data compression would allow the host to attend to other tasks, and significantly decrease the frequency of data transmission errors.

IV. SOFTWARE DESCRIPTION

In this section a description of the software simulation program written to simulate the aircraft information handling system and evaluate the CONOGRAPHIC-12 graphics display terminal is presented.

A. DESIGN CONSIDERATIONS

The primary objective of this study was to evaluate the capabilities of the CONOGRAPHIC-12 graphics display terminal as an interactive display media for six different stations in an aircraft information handling system. The six stations selected were the Aircraft Handling Officer (ACHO), the Flight Deck Officer (FDO), the Hangar Deck Officer (HDO), any one of twelve different Squadron Maintenance Chief stations, the Carrier Airgroup Commander (CAG), and any one of the twelve squadron ready rooms. The objective of the software design was to provide a display of information similiar to that found in the Johnson and Woolley simulation. To accomplish this evaluation, new software tailored to the CONOGRAPHIC-12 display terminal was needed. The software for this project was written in the high level programming language C [11].

Routines used in the interface between the PDP-11/50 and the CONOGRAPHIC-12 terminal utilized in this implementation

and the routines necessary to use the tablet were previously developed at the Naval Postgraduate School [8,5].

The primary objective of the simulaton was to demonstrate the capabilities of the terminal as an interactive device. The desire was to effect a conversational tone, so that the user would be able to interact with the computer in a natural manner, using familiar language and symbols. Specific attention was given to developing a reasonable set of user requests for each station and then to making it simple to make the request and see immediate results. A prompt message continually informed the user of the job sequence, and provided the primary method for acknowledging user requests. Reasonable checks on a user's requests were made prior to proceeding, particuliarly if the request would cause an unintentional change in the data base, or would make it awkward for the user to recover from any request.

It must be stressed that the software that was developed was designed primarily to evaluate the display terminal's capabilities at each station and to provide a reasonable set of user requests which might be expected from the station. It was also felt that routines to force the user to confirm requests were natural and reasonable, if it would be difficult for the user to recover from an erroneous request.

The simulation did not check the validity of the information which a user entered. For instance, it would

allow a user to enter an up status for an aircraft, even if the aircraft were actually down. A down status aircraft is an aircraft which is not in a flyable condition. However, the system did perform some logical checks. For instance, an aircraft actually on the hangar deck may not be moved by the flight deck station.

The method used to alert the user to an unusual request was to flash a warning message. This flashing message appeared in a prompt field. Simultaneously, a bell was rung which was syncronized with the flashing message. It was felt that the audio and visual response by the display were sufficient to alert the user. Requests by the user which were not predefined or were out of sequence were ignored. The display acknowledged the request by erasing the message in the prompt box and then redrawing it. This caused the display terminal to momentarily blink, which gave the user a response but the terminal did not respond to the request.

The display format and user interaction capabilities of the Johnson and Woolley simulation were the standards of comparison used to evaluate the CONOGRAPHIC-12 terminal.

The modular construction of the program allowed for ease of extension to include more options. The present set of user request actions were deamed sufficient to demonstrate the display terminal and host computer's ability to effectively interact with the user.

As presently implemented on the DEC PDP-11/50, the C language supports a powerful data base manipulation feature. The data structure chosen for this implementation could be mapped to a language not having this feature.

The CONOGRAPHIC-12 display terminal was interfaced with a PDP-11/50 computer having 64K bytes of memory and up to 16 million bytes of disk storage. The UNIX operating system was designed to provide the user with a system that was simple and easy to use. Within this framework, powerful software development and debugging tools were provided.

The most significant feature used in this application was the system command language and context editor which could be used to alter the database prior to execution of the program [11]. In this manner, different types of aircraft, different aircraft and different squadrons could be added to or deleted from the simulated onboard complement. This procedure is explained in detail in APPENDIX A, USER'S MANUAL. Although this function was not strictly necessary to evaluate the CONOGRAPHIC-12 display terminal, it provided a more realistic simulated environment which gave more credence to the evaluation results.

The second powerful feature used was the file-device feature. The term file-device will be used to mean the ability to programmatically open an image file and then write the file to the CONOGRAPHIC-12 display terminal without having to have the simulation program process the

file. Use of this feature simulated having access to the CONOGRAPHIC-12 RAM and ROM memory. Files were constructed which simulated preprogrammed ROM fonts, fonts which would reside in the CONOGRAPHIC-12 memory in an actual implementation. This was done in order to remove the code required to regenerate the desired images each time they were required from the simulation program. Construction of the files was done separately, and then the graphic instructions were read from the font file and written to the CONOGRAPHIC-12 display terminal when required. Examples of these files are the files which presently contain the commands to draw the flight deck outline and hangar deck outline. At this time, the other files contain the commands to draw the textual information for the different views.

In an actual implementation, these files would reside in the CONOGRAPHIC-12 display terminal's local ROM or RAM memory and would therefore significantly reduce the transmission time required for drawing subpictures on the terminal. The reduction in transmission time would lessen the danger of a faulty transmission and the resultant complications.

B. DESIGN CHARACTERISTICS

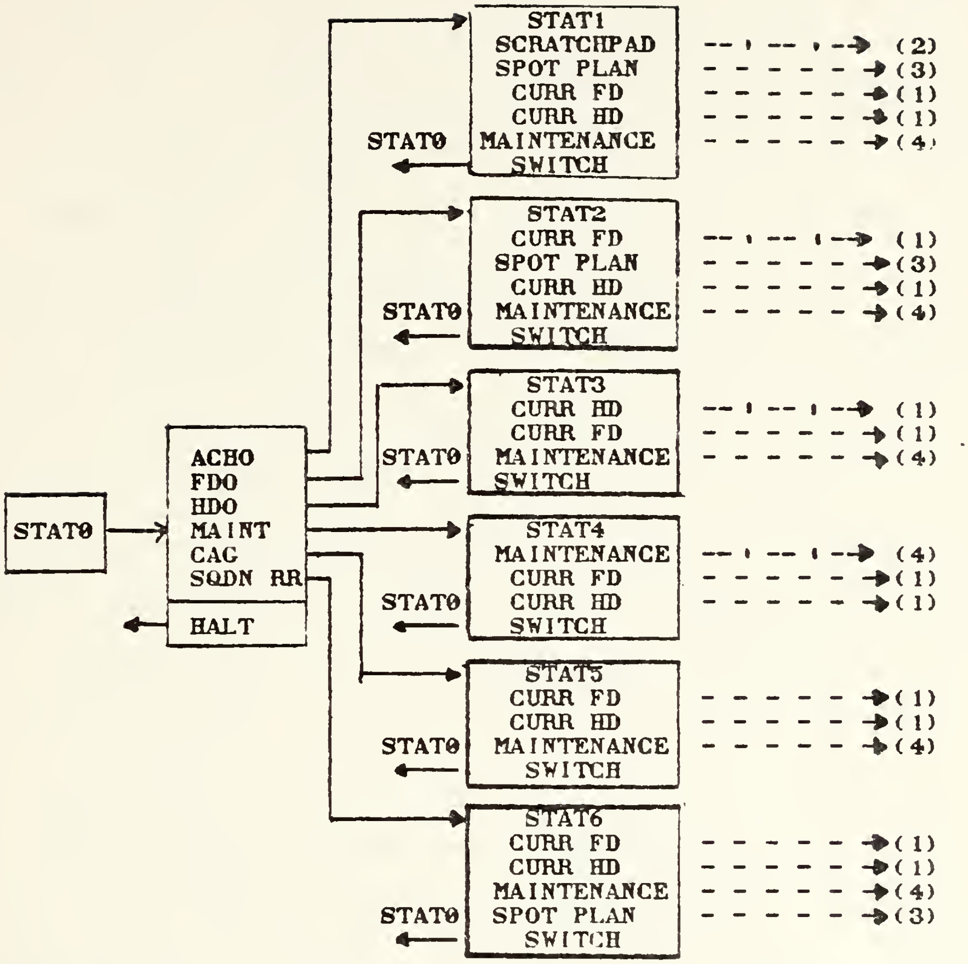
1. Control Structures

The overall logical design of the simulation program was based on a simple control structure which allowed one

CONOGRAPHIC-12 Graphics Display Terminal to simulate any one of six different stations at a time. (See Figure 2). The structure also allowed the appropriate stations to modify the data base, and then have an accurate data base available for use by any one of the other stations. Since the aim of the software was to evaluate the CONOGRAPHIC-12 at each of the stations, two concurrent evaluations were supported by the software for the four stations with interactive capabilities. One evaluation determined the CONOGRAPHIC-12 terminal's capabilities to function as a repeater-only device. This simulated the video signal from one CONOGRAPHIC-12 display terminal driving other displays, a capability the device presently has. The interactive view available at the station was designed to evaluate the terminal as it would be interactively implemented onboard an aircraft carrier.

In order to evaluate the CONOGRAPHIC-12 terminal at each of the interactive stations as both a repeater-only display terminal and an interactive terminal, provision was made to allow the user the option of selecting the desired mode. This was done by displaying a station desired view menu, and then allowing the user to select the interactive view, any of the repeater-only views, or to switch stations.

Selection of the interactive view at an appropriate station gave the user the ability to evaluate the CONOGRAPHIC-12 terminal as a dynamic, interactive display terminal. This view provided for all the views available in



KEY

——→ Functional Control

--·--·→ Modify Access

- - - → Read Only Access

DATA BASE ACCESS

1. Actual Aircraft Location
2. Scratchpad Data Base
3. Spot Plan Data Base
4. Maintenance Data Base

FUNCTIONAL VIEW OF CONTROL STRUCTURE

FIGURE 2

the repeater-only mode, allowed the user to interactively manipulate the data base, and also allowed the user to switch stations. While in the interactive mode, if the user selected one of the views available in the repeater-only mode, return from the view was to the station view selection page associated with that station, instead of the interactive page. This was done to allow the user to work in the interactive mode, simulate having a repeater-only display terminal at the station available for the other views, and then to resume working in the interactive mode. This constraint was introduced to allow a simple control structure and at the same time, realistically simulate having several terminals, including an interactive one, at a station.

The Carrier Airgroup Commander's station was selected as the station demonstrating a proposed implementation of a station without the control structure required by the simulation. This station always functioned as a repeater-only display terminal. The user was allowed to select the initial view by having a station desired view selection page. Once the initial view on the display was selected, the user was allowed to switch views without having to return to the view selection page. Selection of the views available at the Carrier Airgroup Commander's station was done by using the PFK buttons, but a more reasonable implementation would be to switch views in the same manner a regular television channel selector changes

channels.

The other repeater-only station in this simulation, the Squadron Ready Room station, was implemented by allowing the user to select the squadron the station simulated. A view selection page was then displayed which provided a list of the views available at this station. Return from any selected view was always to the view selection page. This control structure allowed the user the ability to evaluate the CONOGRAPHIC-12 terminal as a repeater-only terminal without having to construct special display formats for the selected views. The special formats would be required in order to include a menu. Since this station should also be implemented using the previously described television channel selector mechanism, the constraint of always returning to the station desired view selection page did not affect the evaluation of the terminal, and was a reasonable method for implementing the control structure.

2. Data Base

In order to provide a realistic simulation of an aircraft information handling system, provision was made for two logically distinct manipulations of the data base. The simulation provided a method to alter the data base prior to commencing program execution. Provision was also made to store the data base, as modified by the various stations during program execution, at the end of execution. This provision enabled the state of the data base to be preserved

intact between simulations.

The other distinct manipulation of the data base occurred during program execution when any or all of the interactive stations modified the data base.

The first type of manipulation of the data base made extensive use of the previously described file-device feature. Provision was made to add or delete aircraft, aircraft types or squadrons. Specific procedures are outlined in APPENDIX A, USER'S MANUAL. This provision made use of the editor feature available on UNIX, but could be easily implemented in an actual system. The logical station which would possess this ability would be the Flight Deck Officer's station. This station controlled the aircraft entry to and exit from the onboard aircraft complement.

In an attempt to decrease the amount of secondary storage required to store the data base, only the information associated with the aircraft and squadrons actually on board was stored. The information stored in the data base was sufficient to restore the state of the data base at the end of the last program execution, plus or minus any modifications made to the data base when the simulation was not running. Specific procedures to restore the data base are included in APPENDIX A, USER'S MANUAL.

The interactive data manipulation capablities of the simulation program dealing with the interactive stations are described in the sections of APPENDIX A, USER'S MANUAL,

dealing with the interactive stations.

3. Host Memory Required

Since the primary objective of the software was to provide a realistic simulation of an aircraft information handling system in order to evaluate the CONOGRAPHIC-12 display terminal, minimial consideration was given to the memory requirements of an actual implementation. There were several reasons for this course of action.

Only one CONOGRAPHIC-12 was available for the evaluation. In order to evaluate the display terminal at the six different stations, either six different evaluation programs would have to be written, or one program would have to be able to support all six stations. To realistically evaluate the terminal as a station in the system with access to other stations and the data base, the second course of action was taken. As a result, the code for all the stations and all the data bases were resident in the simulation program.

The second reason was provided by the nature of the study. The aim of the thesis was to evaluate the CONORGAPHIC-12 display terminal, not to design an actual aircraft information handling system. Much of the data used by the simulation program used a 16 bit integer when one bit would suffice. More efficient use of memory could be made by packing and unpacking the data, but the expense in processor time was the determining factor.

The third reason was that in the present implementation of the software interface between the host computer and the CONOGRAPHIC-12 at the Naval Postgraduate School, all the routines to support the display terminal must be loaded into memory, even though most of them were not required for this simulation. A realistic assessment of the memory required would require rewriting the device drivers specifically to support the CONOGRAPHIC-12 for this application.

As a result of the three major reason discussed above, the following figures may be misleading if used to draw conclusions for actual implementation measurements. Any conclusions drawn from them should be made with extreme caution. The following results were obtained by examining the object modules of each module in the simulation program. The numbers are of bytes in decimal. The data base required approximately 19K to support 144 aircraft.

MODULE	PROGRAM CODE	DATA
Initialize	3446	
Setup	3780	226
I/O	3030	650
Utility	5372	240
Maintenance	2226	234
ACHO	3954	242
FDO, HDO	3864	290
Control	1418	256
Total	27,090	2,138

FIGURE 3

4. Special Conventions

In order to evaluate the CONOGRAPHIC-12 display terminal as it was implemented at the Naval Postgraduate School for use in an aircraft information handling system, several features normally available on the display were simulated. Simulation of these features was due to the fact that the software support for the new hardware in the Naval Postgraduate School Computer Laboratory was not yet available under the UNIX time sharing system. Simulation of these features did not effect the evaluation of the CONOGRAPHIC-12 terminal's capabilities, but did introduce some conventions which must be explained.

The joystick/cursor combination was simulated by use of the Vector General Tablet and an outline of the flight deck or hangar deck. The user is required to look away from the display terminal in order to manipulate the stylus. The tablet was functionally equivalent to a joystick/cursor combination.

The extended symbol capability and symbol subroutine capability was simulated in the manner described previously.

V. EVALUATION

A. EVALUATION CRITERIA

In order to evaluate the CONOGRAPHIC-12 graphics display terminal for use in an aircraft information handling system, considerable time was spent in defining the requirements placed on the system by each station. The resulting hierarchical requirements were broken into two subgroups. The first subgroup consisted of those functions deemed mandatory for that station to have, while the second subgroup consisted of those functions which would enhance the individual station's capabilities. Six stations were selected as representative of the different requirements a station must possess. These stations, the Aircraft Handling Officer station, the Flight Deck Officer station, the Hangar Deck Officer station, the Squadron Maintenance Chief station, the Carrier Airgroup Commander Station and the Squadron Ready Room station, were in general agreement with the stations in the system proposed by Johnson and Woolley [7].

In the evaluation, it was felt that each of the stations should have the ability to display graphic information as well as alphanumeric information. This ruled out alphanumeric-only display devices. Reducing the number of views available to a station would change this requirement,

and permit display of those views which are alphanumeric in nature on an alphanumeric-only display device. In a system having several displays at one station, one alphanumeric-only display would be a reasonable implementation as a repeater terminal for the alphanummeric-only display.

In general, it was decided that each station must be capable of reproducing the hangar deck and flight deck outlines, the location of aircraft, maintenance information, messages and menus. Each station would also have to have some means of interacting with the display and hence the host computer. Finally, physical and environmental criteria would have to be met. At the present time, space is always at a premium onboard aircraft carriers. This placed definite constraints on the size of the display terminal, display processor and host processor at each station.

Unusual and differing lighting conditions exist at various air operations stations on present day aircraft carriers. This meant that the display terminal must not be affected by high or low ambient light conditions, and should have some variable intensity capabilities available on the terminal.

Finally, a determination of the best mode of operation for the terminal would have to be made. In this evaluation, the terminal was programmed to be both a repeater-only display device, and an interactive display terminal. The software section explains the reason for this in detail.

The following subsections list specific items to be considered for each individual station which were considered to be the most important characteristics and abilities the station must possess. The requirements which the terminal should possess at any station when used in a repeater-only mode were the same as those listed for the two repeater-only stations, the Carrier Airgroup Commander station and the Squadron Ready Room station.

1. Aircraft Handling Officer's Station

The ACHO's display must provide a working copy of the flight deck, called a scratchpad. The scratchpad is used to temporarily position aircraft in order to develop the desired spot plan. Since this station is used for future planning, changes made on the scratchpad must not affect the data base containing the actual aircraft location.

Once the ACHO is satisfied with the spot plan, it must be recorded, or saved for future reference and distribution. In the current implementation, the ACHO could only create one spotplan. This was considered to be an unnatural restriction, since it limited the ACHO's ability to effectively plan future spots. An improvement to the spot plan generation would be to provide the capability to generate several spot plans. This would give the ACHO the ability to plan several different spot plans to handle different contingencies. This capability could be easily

and economically implemented using current storage techniques, e.g., floppy disk storage. However, the ability to store one spot plan was sufficient to provide a realistic simulation for the evaluation of the CONOGRAPHIC-12 terminal.

In addition to the scratch pad, the ACHO station must be able to display the current flight deck, the current hangar deck, current maintenance status on each aircraft, and current maintenance information for a selected squadron. In order to have this ability, the ACHO station must have interactive capabilities. The station must have some type of locator or coordinate input device and some type of button or selector device. The station must have a selective erase capability. This was required since the station must have the capability of dynamically modifying selected portions of the display. It would be too expensive to transmit an entire display each time the display was modified.

The ACHO station must have the ability to produce hardcopy. Hardcopy capability would be required in order for the ACHO to be able to transmit the spot plan to the Flight Deck Officer for action or implementation.

An enhancing option which must be considered would be the ability to closely inspect selected portions of the display in order to filter out unwanted information or to distinguish portions of the picture which might be difficult

to see otherwise. The capability of hardware zoom would relieve the host computer from having to redimension and redisplay a selected portion of a view to accomplish the scale factor.

2. Flight Deck Officer's Station

The FDO station must be provided with the ability to modify the actual location of aircraft. In the current implemenation, the function of the FDO's station is critical to the accuracy of the data base. The station must have the ability to display the current location of all aircraft in the onboard complement. This station would also be the logical station to use to enter new aircraft and new squadrons into the data base.

In addition to the current flight deck, the FDO station must be able to display the current hangar deck, the spot plan, maintenance information on a single aircraft and maintenance information on a selected squadron.

In order to have this ability, the FDO station must have an interactive capability. The station must have some type of locator or coordinate input device and some type of button or selecting device. The station also needs a selective erase capability, for the same reasons suggested in the ACHO station section.

3. Hangar Deck Officer's Station

The HDO's station must provide the capability to move aircraft on the hangar deck, and between the hangar deck and the transition list. The ability to modify the data base also made the function of this station critical to the accurate state of the data base.

In addition to the current hangar deck, the HDO station must have the ability to display the current flight deck, maintenance information on a single aircraft, or the maintenance informaton on a selected squadron.

Since there was no logical difference between the functions of the HDO station and the FDO station, the HDO station required the same capabilities mentioned in the FDO station section.

4. Squadron Maintenance Chief's Station

The Squadron Maintenance Chief's station must provide the ability to modify the maintenance information for aircraft in the squadron, and to update the maintenance information data base. The function of updating the data base is critical to the accuracy of the maintenance data base. The station must also be easy to interact with because of the number of people who would be using it.

In addition to being able to change information on squadron aircraft the station must have the ability to display the current flight deck and the current hangar deck.

Information contained on these two displays was considered to be important to the scheduling of work on squadron aircraft.

Two enhancing capabilities which the station should contain are hardware zoom and hardcopy. The first capability would allow the user to view the display from a distance. The second capability would be useful in assisting the maintenance chief in the performance of maintenance record keeping duties by providing a record of each aircraft.

5. Carrier Airgroup Commander's Station

The function of the CAG station is to display the current flight deck, the current hangar deck and maintenance information on the selected squadron. This information would be required by the Carrier Airgroup Commander in order to maintain managerial control over the airgroup assets.

The CAG station did not require any interactive capability, but needed some method available at the station to select the different displays.

6. Squadron Ready Room Station

The function of the Squadron Ready Room station is to display the current flight deck, the current hangar deck, maintenance information on that squadron's aircraft and the current spot plan. The squadron maintenance information would be required to assist the squadron commander in

maintaining managerial control. The other three displays would be necessary for briefing flight crews and keeping track of the location of all squadron aircraft. The station did not require any interactive capability, but needed some method available at the station to select the different displays.

B. EVALUATION RESULTS

The evaluation of the CONOGRAPHIC-12 for use as an interactive and static display terminal in air operations required that the software necessary to support the terminal as well as the hardware must be evaluated. The software written for this simulation must be evaluated in order to insure that it provided a realistic simulation environment. The basic objective of the software design was to provide the display format that met the display specifications established by Johnson and Woolley. The second objective was to evaluate the terminal's ability to interact with the user, i.e., the man-machine interface. The third important objective was to implement the extended symbol capability available on the CONOGRAPHIC-12 terminal.

The first of these objectives, that of meeting previously specified display formats, was accomplished with one exception. A decision was made to eliminate the aircraft shapes from the display. The aircraft side number and an orientation arrow contained enough information to be functional without cluttering the display. (See Figure 7).

The additional information about relative size of aircraft did not outweigh the display clutter caused by the aircraft shapes. Several of the ACHO's interviewed for the Johnson and Woolley simulation also noted that aircraft shapes are not required for effective spot plan generation.

The second objective, that of evaluating the man-machine interaction capabilities, was accomplished, although the method of user interaction was modified from the Johnson and Woolley simulation due to the devices available for data entry. The original simulation used the light pen as both a locator device and a menu selection device. Because of the previously discussed hardware and software problem with the joystick and cursor available on the CONOGRAPHIC-12 terminal at the time of this simulation, a Vector General tablet was substituted for the locator device. Use of the tablet did not effect the evaluation of the terminal, but did detract from the simulation since the user had to enter the desired position of the aircraft on the template of the deck drawn on the tablet, thereby interrupting the natural method of interaction with the display screen.

The use of the program function key (PFK) button device instead of a light pen also forced the user to enter each aircraft side number one digit at a time, and then to select another PFK button to confirm the selection. While this method of entry was not considered unnatural, it did not provide the natural selection method available with a light pen. The same comment would also apply to many user

requests which would modify the data base.

The third major objective, that of implementing the extended symbol capability, was not met. The original desire was to place the flight deck and hangar deck outlines in the CONOGRAPHIC-12 memory. During evaluation of the device, both outlines were programmatically loaded into the CONOGRAPHIC-12 memory, but the results were unsatisfactory due to system interface problems. This inability to load the CONOGRAPHIC-12 memory did not effect the evaluation of the terminal at each station, but no statement regarding actual data compression during transmission can be made.

Specific evaluation of the terminal at each station is described in the following subsections dealing with the specific stations. Actual operation of each station is found in APPENDIX A, USER'S MANUAL.

1. Aircraft Handling Officer's Station

The ACHO's station display provided a realistic set of user requests and capabilities. When simulating the ACHO'S station, the CONOGRAPHIC-12 terminal provided the ACHO with a scratchpad, the ability to position aircraft on the display in preparation for a spot plan, and the ability to load the desired spot plan into memory and then display it.

The hardware zoom feature was considered to be indispensable and made close inspection of selected portions

of the display easy. It afforded the user the capability to easily read side numbers of aircraft spotted right on top of the flight deck outline. While the side numbers were readable, the hardware zoom removed any difficulty, especially at any distance from the display terminal.

The complexity of the tasks at this station required a large job menu and tended to give the display a slightly cluttered look. Use of a smaller character size might improve the appearance, but might also make the menu harder to read.

In the evaluation of the CONOGRAPHIC-12 terminal as an ACHO station, the display terminal met the minimum requirements of quick response and the ability to move aircraft. However, the method of interaction using both a locator device and a button device was awkward. Since this station was so critical to the smooth and efficient allocation of aircraft resources, the request and verify method of interaction, described in the software section, was considered too clumsy. This method would probably distract and irritate an ACHO.

Recent developments in touch screen peripheral devices would remove the awkwardness of the present implementation and should make this station as easy to manipulate as the ACHO station in the Johnson and Woolley simulation. The touch screen device would be placed on the front of the display terminal's screen. Presently, two

sides of the device have photoeletric sensors, and the two other corresponding sides have light sources. When the user touched the screen, the device would be able to determine an X-Y coordinate postion. This information would be programmatically used in a manner functionally equivalent to the tablet and the PFK buttons.

2. Flight Deck Officer's Station

The FDO's station display provided a realistic set of user requests and capabilities. When the CONOGRAPHIC-12 terminal was used as an FDO station, it provided the FDO with the ability to control aircraft movement and easily manipulate the data base. The FDO controlled the aircraft on the flight deck, and had three lists of aircraft to manipulate. The three lists were of airborne aircraft, aircraft in transition between the flight deck and the hangar deck, and aircraft in a bingo status. A bingo status aircraft is an aircraft which has been diverted to a shore landing field.

The hardware zoom feature was also considered indispensable at this station for the same reasons discussed in the preceeding section.

The display format was easy to read and understand. It provided a man-machine interface that was easy to operate. The use of the locator device and button device forced a request and verify method of user's desired actions, but since the number of tasks at this station was

less complex than those at the ACHO station, the method was not restrictive or unnatural. Manipulation of the aircraft on the display and in the data base proved to be easy and natural. Response by the terminal to user requests was fast. The CONOGRAPHIC-12 terminal was considered satisfactory for use as a FDO station display terminal.

3. Hangar Deck Officer's Station

The HDO's station display provided a realistic set of user requests and capabilities. The main difference between this station and the FDO's station was that the HDO station had fewer aircraft lists to manipulate. The station controlled the aircraft on the hangar deck and those on the transition list.

Since the function of the HDO station was logically the same as the function of the FDO station, the same evaluation and same results applied at this station. The CONOGRAPHIC-12 terminal was considered satisfactory for use as a HDO station for the same reasons given above in the FDO section.

4. Squadron Maintenance Chief's Station

The Squadron Maintenance Chief's station provided a realistic set of user requests and capabilities. When simulating the Squadron Maintenance Chief's station, the CONOGRAPHIC-12 terminal provided the station with a list of all aircraft in the squadron with their current maintenance

status. An operator could easily manipulate the maintenance information for those aircraft in the squadron using only a button device.

Although the number of tasks at this station was considerable, the display format was not cluttered. The user request and verify method was also used at this station. It was easy to maniplate the terminal and the data base. The terminal responded quickly to the drawing commands from the host processor.

The previously mentioned comments regarding both the hardware zoom and the black on white or white on black modes also were applicable at this station. In addition, the hardware zoom at this station gave the user the ability to easily read the maintenance information display from fifteen feet away. Addition of a hardcopy feature at this station was considered a reasonable method for extracting pertinent maintenance information for use in related maintenance record keeping functions.

It was important for a Squadron Maintenance Chief to have the ability to view both the flight deck and hangar deck displays. These displays contained the information needed regarding aircraft location to enable the squadron maintenance chief to efficiently schedule work.

The ease of interaction, the quick response to user requests and the capability of the CONOGRAPHIC-12 to store predefined symbols such as the hangar deck and the flight

deck, plus the ability to attach hardcopy if required, made the terminal well suited for use at this station.

5. Carrier Airgroup Commander's Station

The CAG's station display provided the ability to view the flight deck display, the hangar deck display and to select any one of the squadrons onboard and view the selected squadron's maintenance information. No interactive capabilities existed at this station, but the present implementation used buttons to select the particular view to be displayed.

Since the need for an interactive capability did not exist at this station, the present CONOGRAPHIC-12 terminal at the Naval Postgraduate School had too many capablities to be used merely as a repeater station. Removal of the input devices and installment of a channel selector type device would be more in line with the requirements of this station. Since this change would require a major engineering change, a more reasonable implementation would be to broadcast the video signal over the aircraft carrier's television circuit and use a conventional television at this station.

6. Squadron Ready Room Station

The Squadron Ready Room station display provided the ability to view the flight deck display, the hangar deck display, that squadron's maintenance information and the spot plan. No interactive capabilities existed at this

station, but a method to switch between desired views was required. The only difference between this station and the CAG station was that this station could only view maintenance information on its own aircraft, and had the ability to view the spot plan. The ability to view the current spot plan was considered a reasonable requirement in order to assist flight crews in determining the expected location of their aircraft for the next launch.

Since the need for an interactive capability did not exist at this station, the CONOGRAPHIC-12 terminal implemented at the Naval Postgraduate School had too many capablities to be used merely as a repeater station, for the same reasons given above in the CAG station evaluation.

VI. CONCLUSIONS

The problems in using the CONOGRAPHIC-12 graphics display terminal as a display terminal in an aircraft information handling system have been discussed. A proposed shipboard implementation using the CONOGRAPHIC-12 terminal has been presented and a simulation of the aircraft information handling system using the CONOGRAPHIC-12 display terminal has been designed and implemented. As a result, several conclusions with respect to the CONOGRAPHIC-12 display terminal can be made.

The fundamental conclusion was that the Hughes CONOGRAPHIC-12 Graphics Display Terminal was ideally suited for this application. This conclusion was supported by several observed facts: (1) the selective erase capability of the terminal gave it a dynamic, interactive capability; (2) based on observations made while working with the simulation program, the terminal and host processor were easy to interact with and responded quickly to user requests; (3) the terminal was capable of duplicating the information content of the Johnson and Woolley display; and (4), the additional hardware capabilities of the terminal, hardcopy, hardware zoom, support of repeater stations, local terminal memory, and two viewing modes, enhanced the capabilities of each of the stations specified in the

Johnson and Woolley proposal.

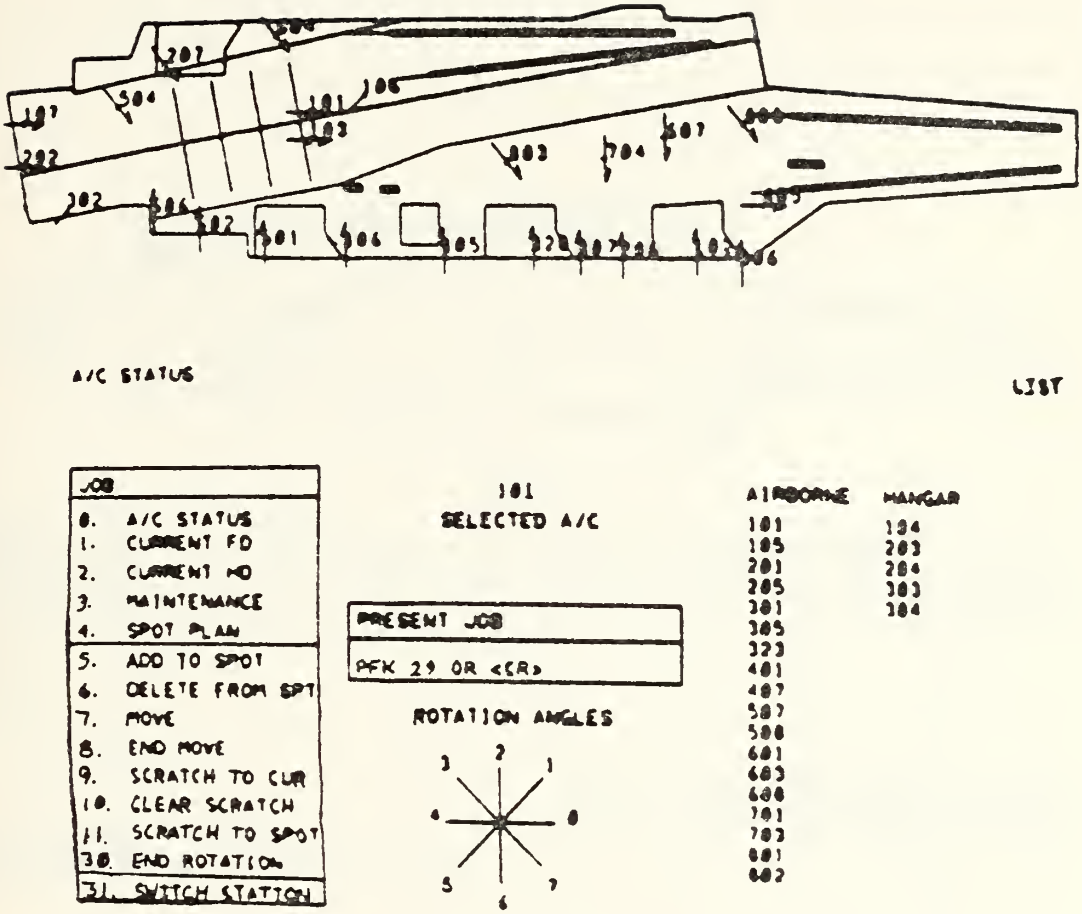
Noteworthy results, and conclusions about the CONOGRAPHIC-12 are as follows:

The CONOGRAPHIC-12 display terminal was very easy to interact with and could be used in a dynamic application. The display was also relatively inexpensive, and for those stations not requiring an interactive capability, the cost could be further decreased by omitting the extra options not required by the station. The CONOGRAPHIC-12 at the Naval Postgraduate School, which included 4K of internal memory, a program function keyboard, a separate scan converter zoom housing, joystick, extended symbol processor, symbol subroutine controller and desk top housing cost about $25K. The basic model 1201 CONOGRAPHIC cost about $13K.

The ability to use raster scan storage tube displays at each station instead of refresh displays significantly reduced the amount of data which had to be transmitted between the host processor and the various displays. Use of the repeater capability of the terminal would completely eliminate any data transmission requirement between the host processor and the repeater station. Use of predefined fonts in the CONOGRAPHIC-12 memory would also significantly reduce the volume of data transmission required by the system.

The most significant conclusion that could be made about the simulation program was that it was effective and gave the user an accurate feel for how the CONOGRAPHIC-12

display terminal would react if actually installed on an aircraft carrier. The simulation was as realistic as the Johnson and Woolley simulation, and provided a good evaluation of the CONOGRAPHIC-12 display terminal's capabilities in an aircraft information handling system.



101
SELECTED A/C

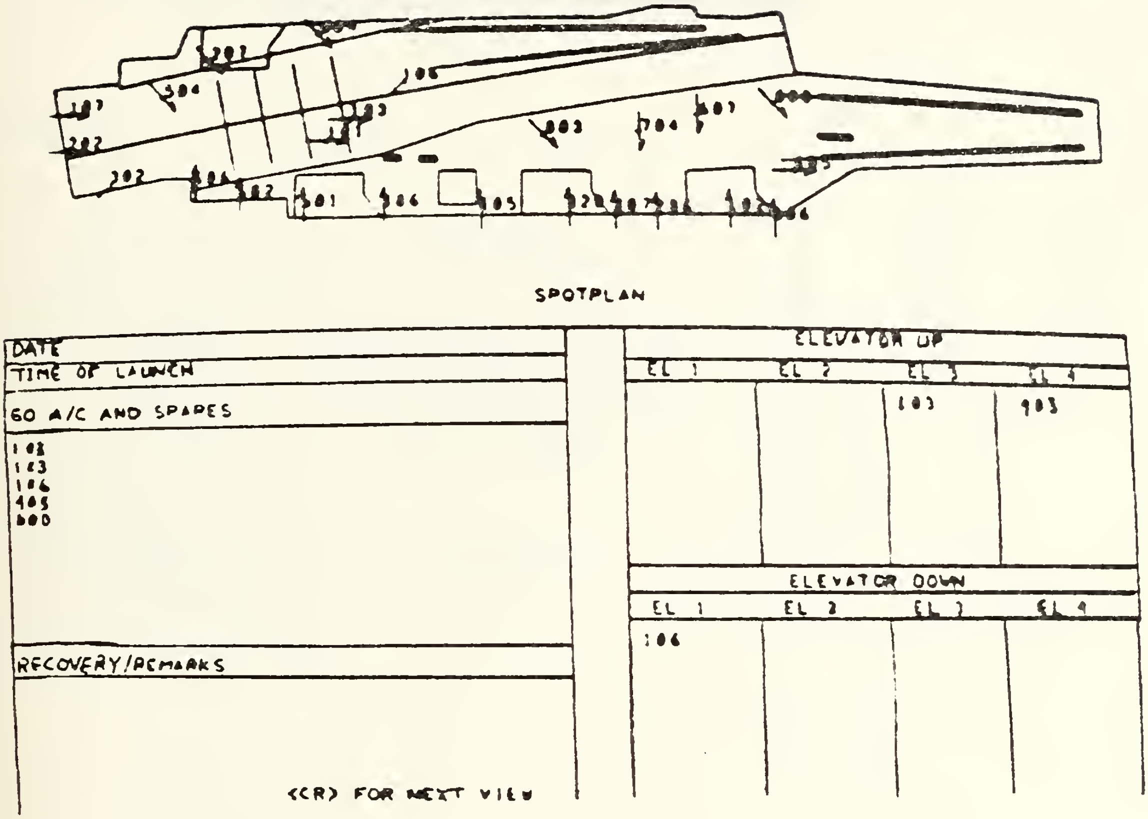
PRESENT JOB

PFK 29 OR <CR>

AIRBORNE	HANGAR
101	104
105	203
201	204
205	303
301	304
305	
323	
401	
407	
507	
500	
601	
603	
600	
701	
703	
801	
802	

ACHO SCRATCHPAD DISPLAY

FIGURE 4



SPOTPLAN

DATE
TIME OF LAUNCH
60 A/C AND SPARES
103 123 106 405 000
RECOVERY/REMARKS
<CR> FOR NEXT VIEW

ELEVATOR UP

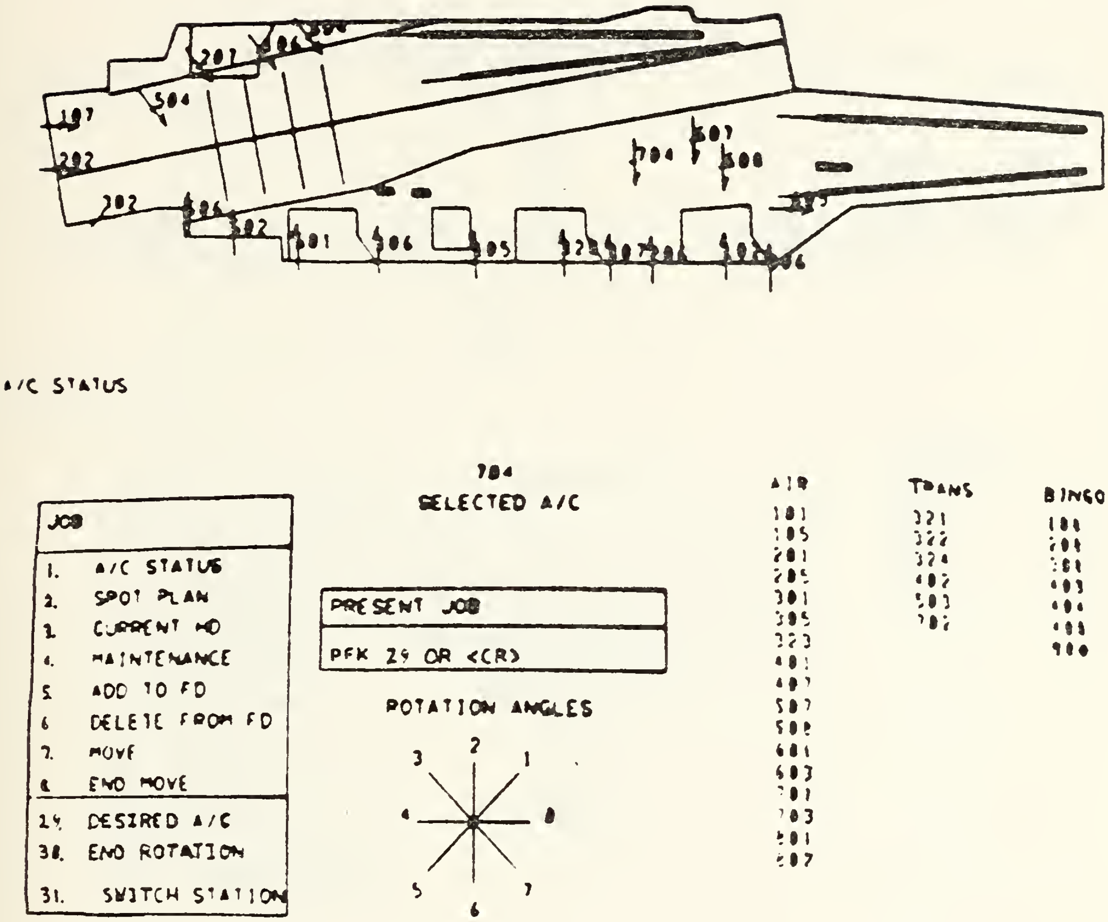
EL 1	EL 2	EL 3	EL 4
		103	903

ELEVATOR DOWN

EL 1	EL 2	EL 3	EL 4
106			

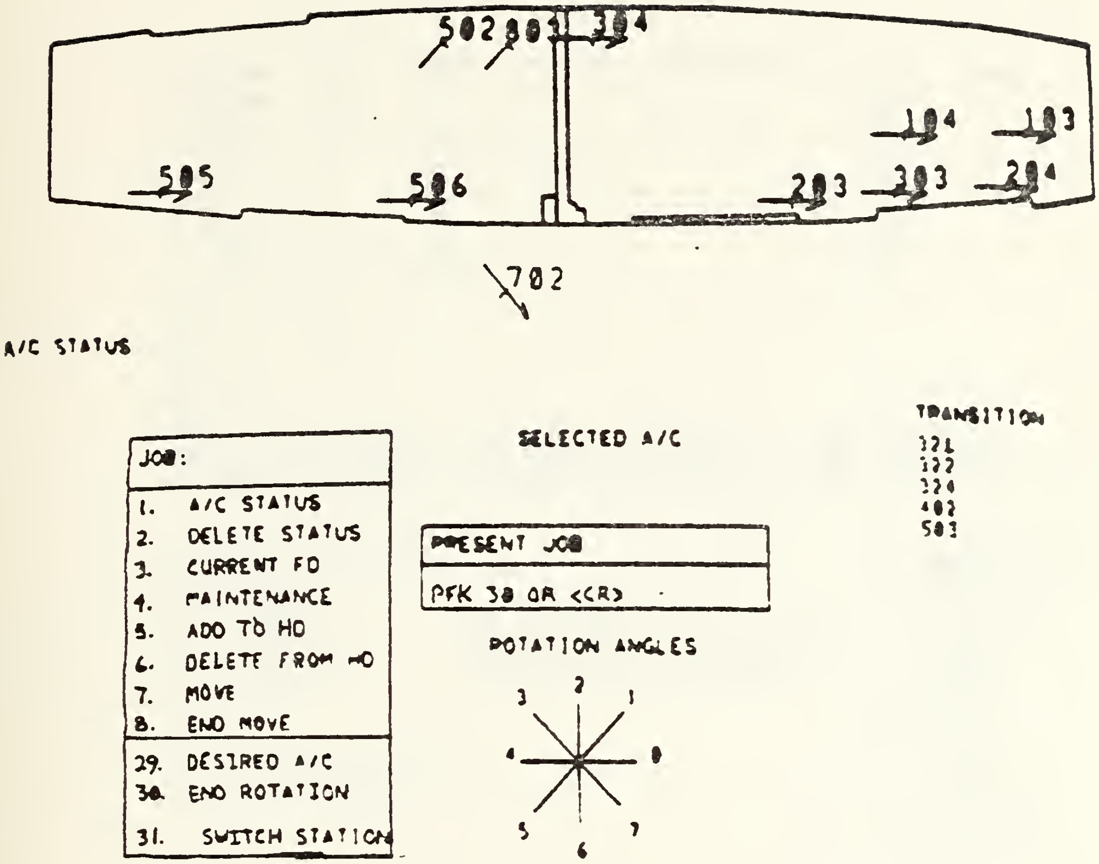
ACHO SPOT PLAN DISPLAY

FIGURE 5



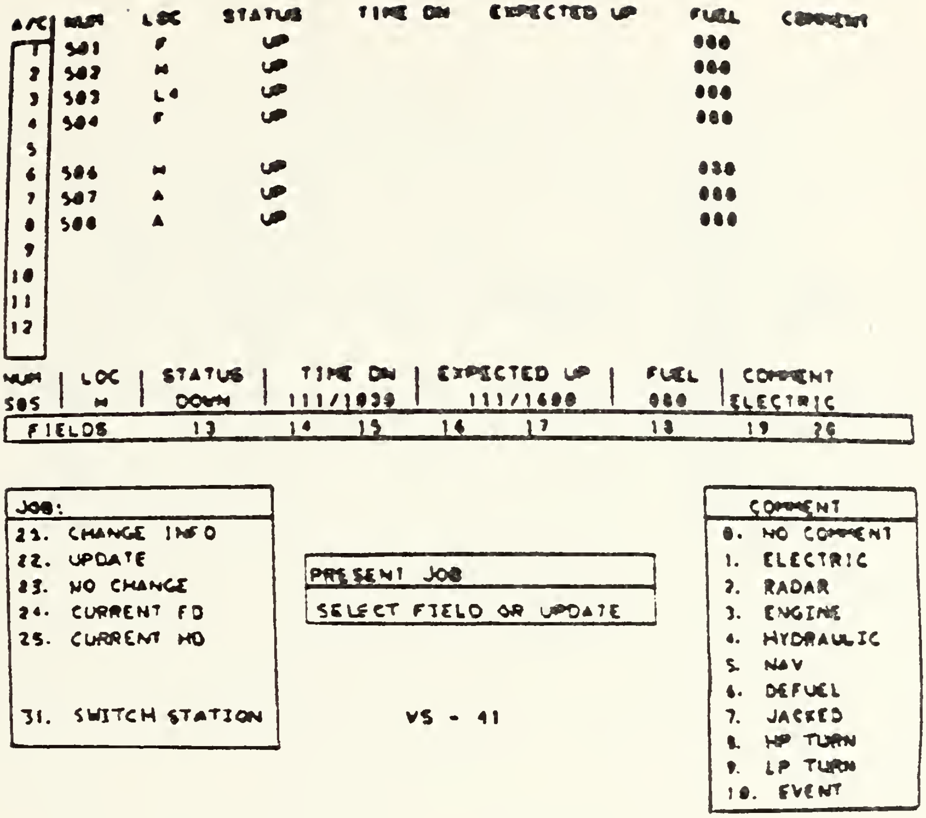
FLIGHT DECK STATION DISPLAY

FIGURE 6



HANGAR DECK STATION DISPLAY

FIGURE 7



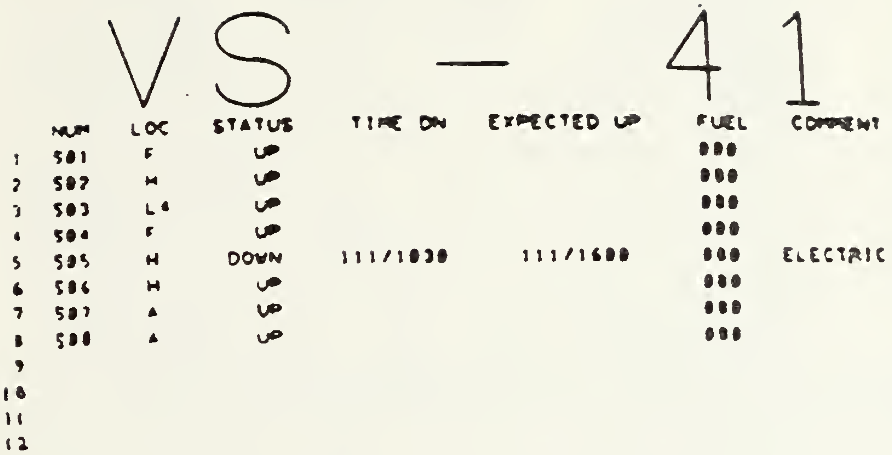
```
A/C| NUM   LOC   STATUS   TIME DN   EXPECTED UP   FUEL   COMMENT
 1 | 501   F     UP                               000
 2 | 502   M     UP                               000
 3 | 503   L4    UP                               000
 4 | 504   F     UP                               000
 5 |
 6 | 506   M     UP                               030
 7 | 507   A     UP                               000
 8 | 508   A     UP                               000
 9 |
10 |
11 |
12 |

NUM | LOC | STATUS | TIME DN  | EXPECTED UP | FUEL | COMMENT
505 |  M  |  DOWN  | 111/1039 |  111/1600   | 000  |ELECTRIC
| FIELDS    13       14   15    16    17       18     19   20 |

JOB:                                                 COMMENT
21. CHANGE INFO                                      0. NO COMMENT
22. UPDATE            PRESENT JOB                    1. ELECTRIC
23. NO CHANGE         SELECT FIELD OR UPDATE         2. RADAR
24. CURRENT FD                                       3. ENGINE
25. CURRENT MD                                       4. HYDRAULIC
                                                     5. NAV
                                                     6. DEFUEL
31. SWITCH STATION          VS - 41                  7. JACKED
                                                     8. HP TURN
                                                     9. LP TURN
                                                     10. EVENT
```

SQUADRON MAINTENANCE CHIEF STATION DISPLAY

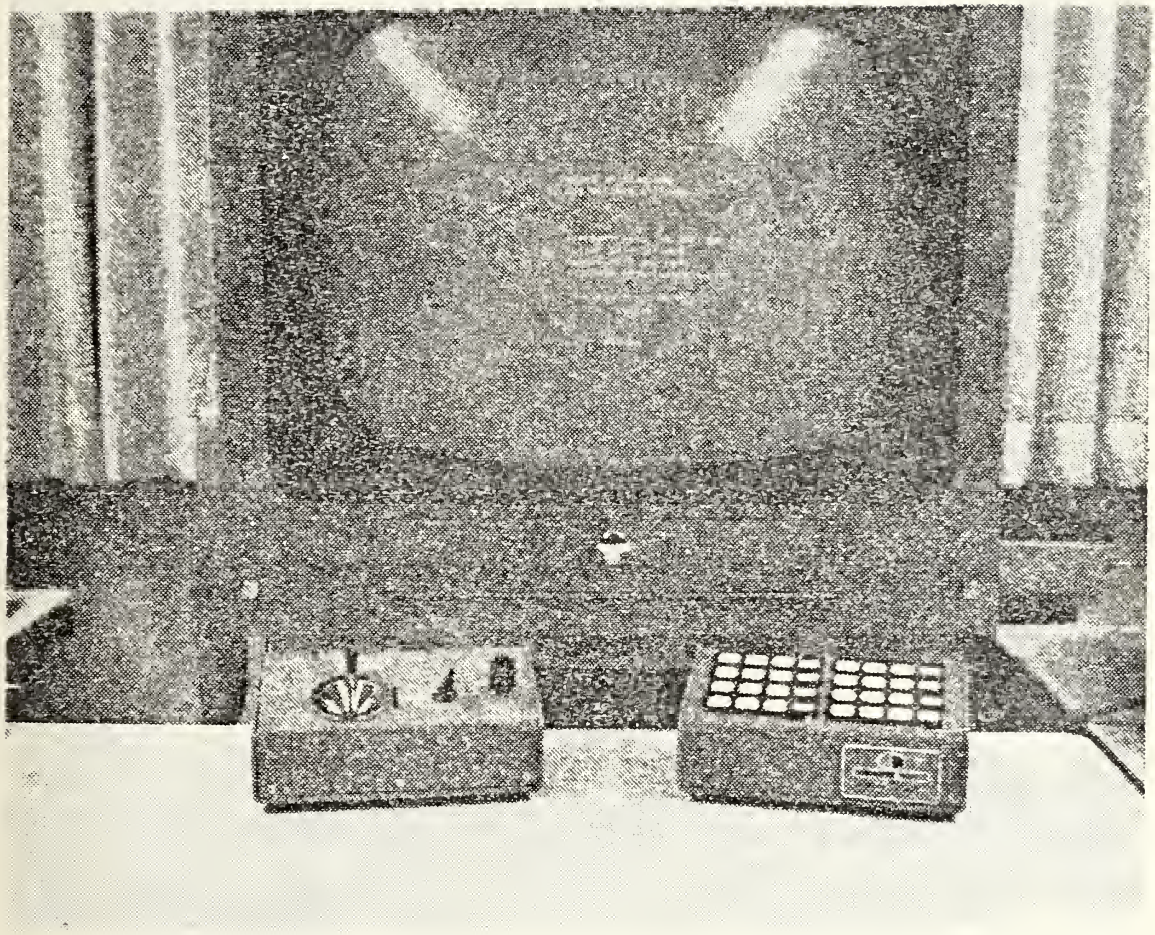
FIGURE 8



```
            VS  —  41
     NUM   LOC   STATUS   TIME DN    EXPECTED UP   FUEL   COMMENT
 1   501   F       UP                               000
 2   502   H       UP                               000
 3   503   L4      UP                               000
 4   504   F       UP                               000
 5   505   H      DOWN    111/1030    111/1600      000   ELECTRIC
 6   506   H       UP                               000
 7   507   A       UP                               000
 8   508   A       UP                               000
 9
10
11
12
```

SQUADRON MAINTENANCE AS REPEATER-ONLY DISPLAY

FIGURE 9



CONOGRAPHIC-12 DISPLAY TERMINAL

FIGURE 10

1. Maintenance Data Base: maint.r

   SQUADRON NAME
   NUMBER OF AIRCRAFT
   Side No.,Loc,Status,Down Day,Down Time,Up Day,Up Time,Fuel,Comment,Event

2. Aircraft Location Data Base: acho.r

   NUMBER OF AIRCRAFT
   Side No.,Loc,Direction,Go,Type,X-coord,Y-coord,Rotation

3. Scratch Pad Data Base: scr.r

   NUMBER OF AIRCRAFT
   Side No.,Location,Direction,Go,X-coord,Y-coord,Rotation

4. Spot Data Base: spot.r

   NUMBER OF AIRCRAFT
   Location,Go,X-coord,Y-coord,Rotation

DATA BASE MODIFICATION EXAMPLES

FIGURE 11

VII. APPENDIX A - USER'S MANUAL

Brief descriptions of the various parameters provided for user interaction with the PDP-11/50-CONOGRAPHIC-12 system are given in the main body of this thesis. The information contained in this appendix is intended to provide a guide to the user in the operation of the system.

A. INTRODUCTION

The following sections contain the specific instructions for performing the functions incorporated into the evaluation program at each simulated station. Instructions which appear on the screen are kept to a minimum and are prompting in nature. It is assumed that all operators would receive training on the system and excessive memory would be consumed to store detailed instructions. Secondly, detailed instructions would detract from the appearance of the display by adding unnecessary clutter.

All desired changes on the display are made by pressing a Program Function Key (PFK) and using the simulated cursor. The list of available actions at each station, the menu, contains the number of the appropriate PFK button which is associated with the action.

Since only one CONOGRAPHIC-12 device was available, the initial view appearing will contain a list of the available stations. Selection by the PFK buttons enables the operator to select the desired simulation station. A page will then appear which allows the operator to select a view from that station, or switch stations.

The four stations with interactive data manipulation capabilities, the Aircraft Handling Officer (ACHO), the Flight Deck Officer (FDO), the Hangar Deck Officer (HDO) and the Squadron Maintenance Chief, have one view with interactive capabilities. This view also has the capability to select any other view available to the operator at that station. Return from a selection of any page but the interactive page returns the operator to the initial page for the simulated station, unless the switch station function has been selected. In that case, the initial station select page appears and allows the operator to select the new desired station, or halt the program.

In an actual implementation, the functions of the selected station page and the interactive page could be implemented by having several terminals at the station. One terminal would be used for the interactive display, and the others used as repeater terminals. The present system is not a model of an actual implementation and was designed to allow evaluation of the terminal at each of the six stations as both a repeater-only display and/or a dynamic, interactive display terminal. A detailed explanation of the

control structure is found in the software description section of the thesis.

The Carrier Airgroup Commander (CAG) station was selected to demonstrate the proposed implementation of an actual stand-alone station without the previously mentioned artificial constraint.

The evaluation program was designed with the concepts of human engineering in mind. One of the attributes of a human engineered system is its ease of use, which implies ease of error correction. This characteristic was one of several implemented in the simulation. Entry and request verification provides a mechanism to prevent and recover from operator errors.

B. AIRCRAFT HANDLING OFFICER STATION

Having selected the Aircraft Handling Officer's station, the operator will see a list of the views available at this station. The views are the scratchpad, the spot plan, the current flight deck, the current hangar deck, and squadron maintenance. The operator also has the option of switching stations at this time.

The interactive view at this station is the scratchpad. Selection of the appropriate PFK button for the remaining views will cause the display to erase and then display the selected view. The prompt message "<CR> FOR NEXT VIEW" also appears on the display. To change views, press any PFK

button. The display is erased and then displays the initial station view selection page for this station. Selection of a PFK button which does not have a corresponding view will cause a flashing "INVALID SELECTION" message to appear in the lower middle of the display. The operator then must make an appropriate PFK button selection.

The following sections describe the functions of the requested jobs available to the operator at this station. Each view will be described, along with the functions available at this station. The interactive view is described first, and the function of each PFK button is described.

1. Scratchpad - PFK 1

Selection of this PFK button enters the operator into the interactive view available at this station. Refer to Figure 4 for a picture of the display in this mode. The operator has a display of the flight deck outline, all aircraft on the scratchpad flight deck with their side number, location and orientation, a menu of the jobs available at this station, a prompt message box, an aircraft orientation angle guide, and lists of aircraft side numbers. The number of lists available depends on the state of the display. If the ACHO previously selected the "Clear Scratchpad" function, the list displayed will be of all aircraft currently onboard except for those in a bingo status, otherwise the display will have a list of airborne

aircraft and a list of aircraft on the hangar deck. A bingo status aircraft is an aircraft which has been diverted to a shore landing field.

Specific instructions for the operator to operate the station in the interactive mode follow. The prompt message "SELECT JOB" appears in the prompt box, and the display terminal waits for the operator to select a job from the job menu.

a. A/C Status - PFK 0

This PFK button allows the operator to obtain the maintenance status on one aircraft. The prompt message "ENTER SIDE NUMBER" appears in the prompt box and the operator enters the aircraft side number one numeral at a time using the PFK buttons. The numeral is echoed back to the operator above the SELECTED A/C text. Once the operator has entered the three numeral side number, the prompt message "PFK 29 OR <CR>" is displayed in the prompt box. Selecting PFK button 29 will then display the maintenance status for that aircraft, unless the aircraft is not in the onboard complement.

If the selected aircraft is not in the onboard complement, a flashing "A/C NOT IN COMPLEMENT" message will appear in the prompt box, followed by an "ENTER SIDE NUMBER" prompt. If the operator has mistakenly entered the side number of an aircraft which is not desired, press any PFK button except PFK button 29. The prompt message, "ENTER

SIDE NUMBER", will again appear in the prompt box, and the operator proceeds as before.

Maintenance information on the selected aircraft will remain on display until the operator selects the next desired job. At this time, the prompt box will have the message "SELECT JOB", and the simulated station will wait for the operator to select a new job.

b. Current FD - PFK 1

Selection of the CURRENT FD PFK button will erase the display and then display the current flight deck. The prompt message "<CR> FOR NEXT VIEW" will appear at the bottom of the display. When the operator has finished viewing the current flight deck, selection of any PFK button will erase the display and display the initial desired view menu for this station.

c. Current HD - PFK 2

Selection of the CURRENT HD PFK button will erase the display and then display the current hangar deck. The prompt message and return to the initial desired view selection page for this station is the same as described above in the CURRENT FD subsection.

d. Maintenance - PFK 3

Selection of the MAINTENANCE PFK button will erase the display and then display a list of squadrons

currently on board. The operator then presses the appropriate PFK button corresponding to the desired squadron, and the complete maintenance status for the selected squadron is displayed. (See Figure 9). The prompt message and return is the same as described above.

e. Spot Plan - PFK 4

Selection of the SPOT PLAN PFK button will erase the display and then display the current spot plan. (See Figure 5). Selection of this button does not cause an update of the spot plan, but displays the last spot plan created by the ACHO. The prompt message and return is the same as described above.

f. Add To Spot

Selection of the ADD TO SPOT PFK button allows the operator to add an aircraft to the scratch pad. The operator enters the aircraft side number in the same manner described above under A/C STATUS. The selected aircraft will appear just below the flight deck outline and the prompt message "PFK 1 IF GO" appears in the prompt box. Selection of PFK button 1 will place the aircraft in the list of aircraft designated as the aircraft to be launched when the spot plan is updated. Selection of any other PFK button will allow the operator to place the aircraft on the scratchpad for location transfer on the spot plan.

If the aircraft is actually on the hangar deck, the prompt message "WHICH ELEVATOR" appears in the prompt box. The operator enters the appropriate PFK button corresponding to the desired elevator. The aircraft side number will be entered into the correct array for the elevator traffic on the spot plan. The aircraft will then appear on the view just below the flight deck outline.

The next prompt message, "PFK 30 OR INPUT ANGLE" appears in the prompt box. At this time the operator may change the orientation of the aircraft, or confirm the present orientation. The operator presses PFK button 30 if satisfied with the present aircraft orientation. To change the aircraft orientation, the operator selects the desired orientation by pressing the appropriate PFK button corresponding to the ROTATION ANGLE text available on the display. Currently eight different aircraft orientations are available. The allowed orientations will rotate the aircraft to correspond to the operator's choice. Any angle selected which is not on the current ROTATION ANGLE text will cause the aircraft to be oriented toward the bow of the aircraft carrier.

When the operator is satisfied with the aircraft orientation, press PFK button 30, otherwise, press any other PFK button. The prompt message "PFK 30 OR <CR>" will be displayed to remind the operator of the sequence.

Upon completion of the aircraft orientation sequence, the prompt message "SELECT POSITION" appears in the prompt box. In the current implementation, the operator positions the aircraft using the tablet pen and the tablet overlay. Depress the pen on the tablet at the desired position, and the aircraft will appear on the flight deck outline at the selected position. The prompt message "PFK 8 OR <CR>" will appear in the prompt box.

If the operator is satisfied with the aircraft location, press PFK button 8. This causes the aircraft location to be entered into the scratchpad data base and the prompt message "SELECT JOB" to appear in the prompt box, completing the ADD TO SPOT sequence.

If the operator is not satisfied with the aircraft position, press any PFK button except PFK button 8. This will cause the "SELECT POSITION" prompt message to appear in the prompt box, and the operator selects the new desired position. The aircraft will be erased from its present position and drawn in the new position.

g. Delete from Spt - PFK 4

Selection of the DELETE FROM SPT PFK button will prompt the operator for the aircraft side number. The operator will next see a "WHICH ELEVATOR" prompt message. An appropriate entry causes the aircraft to disappear from the view and to be placed in the correct list for the spot plan.

h. Move - PFK 7

Selection of the MOVE PFK button allows the operator to move an aircraft from one position to another on the scratch pad and change or confirm the aircraft's orientation. The operator enters the aircraft side number in the manner described above, and the aircraft will be erased from the scrachpad and appear just below the flight deck. The prompt message "PFK 30 OR <CR>" appears in the prompt box and the operator confirms the aircraft orientation, or selects a new one at this time, using the same procedures outlined above. When the operator is satisfied with the aircraft orientation, select the new aircraft position in the same manner outlined above.

i. Scratch to Curr - PFK 9

Selection of the SCRATCH TO CURR PFK button will erase all the aircraft on the scratchpad and then initialize the scratchpad data base to match the actual aircraft location data base. It will then draw the aircraft currently on the flight deck, and update the airborne and hangar lists on the scratchpad display. Selection of this PFK button will cause a flashing "SCRATCH TO CURRENT ???" message to appear in the prompt box. If the operator really desires to initialize the data base to the actual aircraft location, reselect PFK button 9.

j. Clear Scratch - PFK 10

Selection of the CLEAR SCRATCH PFK button will erase all the aircraft on the scratchpad and in the two lists. It then lists all the onboard aircraft side numbers, except those in a bingo status, on an available list. Selection of this PFK button will cause a flashing "CLEAR SCRATCH ???" message to appear in the prompt box. If the operator really desires to place all aircraft on the available list, reselect PFK button 10.

k. Scratch To Spot - PFK 11

Selection of the SCRATCH TO SPOT PFK button will transfer all aircraft which have been manipulated by the operator to the spot plan, erase the display and display the current spot plan. Selection of this PFK button will cause a flashing "SCRATCH TO SPOT ???" message to appear in the prompt box. If the operator really desires to update the spot plan with the information from the scratchpad, reselect PFK button 11. The function of this PFK button will alter the current spot plan. The operator should select PFK button 4 to view the current spot plan without modifying it.

l. Switch Station - PFK 31

Selection of this PFK button erases the display and then displays the initial station selection page. Use of the SWITCH STATION PFK button will bypass the station view selection page at this station and allow the operator

the option of simulating a new station, or halting the simulation.

2. Spot Plan - PFK 2

Selection of this PFK button allows the operator to view the current spot plan with the terminal functioning in the repeater-only mode. The display will be erased, and then draw the current spot plan. In addition, the prompt message "<CR> FOR NEXT VIEW" is displayed on the lower left side of the display. When the operator has finished viewing the current spot plan, press any PFK button. The display will be erased, and then display the station view selection page for this station. Return from this view is the same as previously described in the ACHO section.

3. Current Flight Deck - PFK 3

Selection of this PFK button allows the operator to view the current flight deck. The procedure to change views is the same as outlined in the preceeding section.

4. Current Hangar Deck - PFK 4

Selection of this PFK button allows the operator to view the current hangar deck. The procedure to change views is the same as that outlined above.

5. Squadron Maintenance - PFK 5

Selection of this PFK button erases the display and then displays a list of the squadrons currently onboard.

The operator may select the appropriate PFK button corresponding to the desired squadron. Having selected the squadron, the display is erased and then displays the selected squadron's name and the maintenance information for the squadron. (See Figure 9). Return from this view is the same as described for returning from the spot plan view.

6. Switch Station - PFK 31

Selection of the SWITCH STATION PFK button will erase the current display and return the operator to the initial station selection view. At this point, the operator may select the appropriate PFK button corresponding to a new simulation station, or the operator may halt the program. The SWITCH STATION PFK button is the only means of entering another station's simulated environment.

C. FLIGHT DECK OFFICER STATION

Having selected the Flight Deck Officer's station, the operator will see a list of the views available at this station. The views are the current flight deck, the current hangar deck, the spot plan, and squadron maintenance. The operator also has the option of switching stations at this time.

The interactive view at this station is the current flight deck. Selection of the appropriate PFK button for the remaining views will cause the display to erase and then display the selected view. The prompt message "<CR> FOR

NEXT VIEW" also appears on the display. Pressing any PFK button allows the operator to change views. The display is erased and then displays the initial station selection page of views available at this station. Selection of a PFK button which does not have a corresponding view will cause a flashing "INVALID SELECTION" message to appear in the lower middle of the display. The operator then must make an appropriate PFK selection.

The following sections describe the jobs available to the operator at this station. Each view will be described, along with the functions available at this station. The interactive view is described first, and the function of each PFK button at this view is described.

1. Current Flight Deck - PFK 1

Selection of this PFK button enters the operator into the interactive view available at this station. Refer to Figure 6 for a picture of the display in this mode. The operator has a display of the flight deck outline, all aircraft on the deck with their side number, location and orientation, a menu of the jobs available at this station, a prompt message box, an aircraft orientation angle guide, and three lists of aircraft side numbers. The three lists are lists of those aircraft which are airborne, in a transition status between the flight deck and the hangar deck, and a list of those aircraft in a bingo status. Specific instructions for the operator to operate the station in this

mode follow. The prompt message "SELECT JOB" appears in the prompt box, and the display terminal then waits for the operator to select a job from the job menu. To select the desired job, the operator must press the PKF button corresponding to that job. A description of each of the functions available at this station follows.

a. A/C Status - PFK 1

To obtain the maintenance status on one aircraft, the operator selects the A/C STATUS PFK button. This causes an "ENTER SIDE NUMBER" prompt message to appear in the prompt box. The job sequence is identical to that described in detail in section B.1.a, with the same results. Maintenance information on the selected aircraft will remain on display until the operator selects the next desired job. At this time, the prompt box will have the message "SELECT JOB", and the display will wait for the operator to select a new job.

b. Spot Plan - PFK 2

Selection of the SPOT PLAN PFK button will erase the display and then display the current spot plan. The job sequence is identical to that described in section B.2.

c. Current HD - PFK 3

Selection of the CURRENT HD PFK button will erase the display and then display the current hangar deck. The prompt message and return to the initial desired view

page for this station is the same as described in section B.1.c.

d. Maintenance - PFK 4

Selection of the MAINTENACE PFK button will erase the display and then display a list of squadrons on board. The job sequence is the same as that described in section B.1.d.

e. Add To FD - PFK 5

Selection of the ADD TO FD PFK button allows the operator to add an aircraft to the flight deck from the airborne list, the transition list, or the bingo list. The procedure is identical to that described in detail in section B.1.f.

f. Delete From FD - PFK 6

Selection of the DELETE FROM FD PFK button allows the operator to delete an aircraft from the flight deck and place it on the airborne list, the transition list or the bingo list. The procedure is identical to that described in section B.1.g. If the aircraft is not on the flight deck, the flashing message "A/C MOVEMENT NOT ALLOWED" will appear in the prompt box, followed by an "ENTER SIDE NUMBER" prompt.

If the aircraft is on the flight deck, it will disappear from the flight deck and appear just below the

flight deck. The prompt message "1-AIR, 2-TRANS, 3-BINGO" then appears in the prompt box. Selection of PFK button 1 or 3 erases the aircraft from the view and places it on the airborne or bingo list as appropriate. Selection of PFK button 2 will cause the prompt message "WHICH ELEVATOR" to appear in the prompt box.

The operator then presses the appropriate PFK button corresponding to elevator 1 through elevator 4. An invalid selection will cause a flashing "INVALID SELECTION" selection message to appear in the prompt box, followed by a "WHICH ELEVATOR" message. Having selected the appropriate PFK button, the aircraft is erased from the display and its side number appears on the transition list, followed by a "SELECT JOB" message in the prompt box.

g. Move - PFK 7

Selection of the MOVE PFK button allows the operator to move an aircraft from one position on the flight deck to another position on the flight deck, and change the selected aircraft's orientation. The procedure is identical to that described in section B.1.h, except that the station is not allowed to move aircraft which are not on the flight deck.

h. Switch Station - PFK 31

Selection of the SWITCH STATION PFK button will erase the current display and return the operator to the

initial station selection view in the same manner described in section B.1.1.

2. Current Hangar Deck - PFK 2

Selection of this PFK button allows the operator to view the current hangar deck in a repeater-only mode. This view is the same as that described in detail in section B.4.

3. Spot Plan - PFK 3

Selection of this PFK button allows the operator to view the current spot plan. (See Figure 5). The procedure to change views is identical to that described in section B.2.

4. Squadron Maintenance - PFK 4

Selection of this PFK button erases the display and displays a list of the squadrons currently onboard. The procedure is the same as that described in section B.5.

5. Switch Station - PFK 31

Selection of this PFK button erases the display and then displays the initial station selection page, in the same manner described in section B.6.

D. HANGAR DECK OFFICER DISPLAY

Having selected the Hangar Deck Officer's station, the operator will see a list of the views available at this station. The views are the current hangar deck, the current flight deck, and squadron maintenance. The operator also has the option of switching stations at this time.

The interactive view at this station is the current hangar deck. Selection of the appropriate PFK button at this station for the remaining views is identical to the description given in the Flight Deck Officer's station section. The following section will describe the function of the PFK buttons on the interactive page for this station. Refer to Figure 7 for a picture of the display in this mode. Since many of the functions of this station are identical to those on the Flight Deck Officer's display, attention will be given to the differences between this station and the flight deck station.

1. Current Hangar Deck - PFK 1

Selection of this PFK button enters the operator into the interactive view available at this station. The operator has a display of the hangar deck, all aircraft on the deck with their side number, location and orientation, a menu of the jobs available at this station, a prompt message box, an aircraft orientation angle guide, and a list of aircraft in transition between the flight deck and the hangar deck. Operation of this station is identical to the

procedures described for operating the Flight Deck station. This station does not have the capability to view the spot plan. Aircraft may only be entered onto the hangar deck via the transition list, and may only be erased from the view by placing the aircraft on the transition list.

The procedures to enter the aircraft onto the hangar deck are identical to the procedures for entering aircraft onto the flight deck. To delete an aircraft from the hangar deck, the operator selects the DELETE FROM HD PFK button. The prompt message "WHICH ELEVATOR" will appear in the prompt box. It is assumed the aircraft will be transitioning to the flight deck, and the operator is only required to enter the elevator number corresponding to the elevator which will be used. The same restrictions regarding aircraft movement and selection given for the flight deck are applicable at this station.

2. Delete Status - PFK 2

This station gives the operator the option of deleting the maintenance status information on a selected aircraft as a separate function. Selection of the DELETE STATUS PFK button will erase the information on the aircraft currently being displayed. It is not necessary for the operator to delete the aircraft maintenance status, since selection of any job at this station will automatically delete it, but the operator is given the option of erasing the information without having to initiate another job

request.

Function of the PFK buttons associated with the repeater-only mode are identical to those described above for the Flight Deck Officer station.

E. MAINTENANCE DISPLAY

Having selected the Squadron Maintenance Chief Station, the operator will see a list of the squadrons currently on board. The operator selects the appropriate PFK button corresponding to the simulated squadron. The next view will have a list of the available views at this station. The views are maintenance, current flight deck and current hangar deck. The operator may also chose to switch stations at this time. Selection of the corresponding PFK button will display that view. When the operator has finished viewing the current flight deck or current hangar deck, pressing any PFK button will return the operator to the desired view selection page for the Squadron Maintenance Chief. The station still remains as the previously selected squadron.

To select the interactive data manipulation view, the operator selects Maintenance Chief. Refer to Figure 8 for a picture of the display in this mode. Specific instructions to operate this station follow.

1. Squadron Maintenance - PFK 1

Having selected the interactive view, the prompt message "SELECT JOB" appears and the display terminal then waits for the operator to select a job from the job list. To select the desired job, select the PFK button on the job list.

a. Change Info - PFK 21

Selection of the UPDATE or NO CHANGE PFK buttons will be ignored unless the operator has previously selected the CHANGE INFO button.

Selection of the CHANGE INFO PFK button will prompt the operator to select an aircraft with the message "SELECT AIRCRAFT". The operator selects the desired aircraft by pressing the PFK button corresponding to that aircraft. An invalid selection will cause the flashing message "INVALID SELECTION" to appear in the prompt box, and then reprompt the operator to select an aircraft. The selected aircraft will then appear above the field box. If the operator has selected the wrong aircraft press the NO CHANGE button and the aircraft information will disappear from the field box and reappear in the list of squadron aircraft. At this time, the operator must select the CHANGE INFO PFK button and enter the new desired aircraft.

The prompt message "SELECT FIELD OR UPDATE" will now appear in the prompt message box. Selection of the

appropriate field PFK button will enable the operator to change the information in that field. A discussion of each field PFK button follows.

(1) Status - PFK 13.

Selection of this field will cause an automatic change in fields 13,14,15,16 and 17. If the aircraft was down, field 13 will be changed to "UP" and the Down Day, Down Time, Expected Up Day and Expected Up Time fields will be blanked. If the aircraft were originally up, selection of field 13 will place "DOWN" in the status field and asterisks will appear in the remaining day and time fields. The operator then selects the appropriate field and enters the new day or time as appropriate by selecting the digits one at a time on the PFK buttons. The only allowed digits are 0-9 and selection of any other button will flash an "INVALID SELECTION" message in the prompt message box. If the operator enters an incorrect digit, the entry for that field must be completed. At this time, reselect the field and reenter the data. When satisfied with the data for that field, select the next field PFK button to update the next field. Selection of PKF 13 does not force the operator to sequentially select field 14,15,16 or 17 PFK buttons. In fact, the operator may select any field, incuding field 13. Reselection of field 13 will switch the status field, but will not reenter the day and time fields. The data for these fields is still in the data base, and reentry of the aircraft change sequence will restore the

fields to view. The simulation approach was that an operator would not switch the STATUS field several times on one job request. Selection of NO CHANGE at this time places the aircraft back on the information list with its original information displayed.

(2) Down Day - PFK 14.

Selection of this field results in the prompt message "Enter Down Day", then allows the operator to enter the three digit julian date. The only digits allowed are 0-9 and any other selection will result in a flashing "INVALID SELECTION" message, followed by a reprompt. As the operator enters the digits, they appear in their corresponding position in the field update box. An invalid entry at this time means the operator must finish the string and then reselect the field and reenter the data.

(3) Down Time - PFK 15.

Selection of this field results in the prompt message "Enter Down Time", then allows the operator to enter data in the same manner described above.

(4) Expected Up Day - PFK 16.

Selection of this field results in the prompt message "Enter Expected Up Day", then allows the operator to enter data in the same manner described above.

(5) Expected Up Time - PFK 17.

Selection of this field results in the prompt message "ENTER EXPECTED UP DAY", and allows the operator to enter data in the same manner described above.

(6) Fuel - PFK 18.

Selection of this field results in the prompt message "ENTER FUEL" and allows the operator to enter data in the same manner with the same restrictions described in the DOWN DAY subsection.

(7) Comment - PFK 19.

Selection of this field results in the prompt message "ENTER COMMENT". The operator then selects the PFK button corresponding to the standard maintenance descriptions listed in the COMMENT menu. Selection of "NO COMMENT" blanks the field, otherwise the selected comment appears in the field. If "EVENT" is chosen, the prompt message "ENTER EVENT" appears and the PFK corresponding to the event number is selected.

b. Update - PFK 22

Selection of this PFK button enters the information which is displayed in the field box for the aircraft in the data base. Once the operator has finished modifying the information for one aircraft, select the UPDATE or NO CHANGE PFK from the job menu. If the operator

selects the NO CHANGE button, the prompt message "UPDATE ???" will appear to verify that the operator has elected not to update the information fields. Selection of the UPDATE PFK button will update the data base and move the aircraft information fields back to the aircraft lists in the updated version. Selection of the NO CHANGE PFK button will restore the aircraft to its place on the aircraft list in its original state.

c. No Comment - PFK 23

Selection of this field will not modify the data base on the selected aircraft. A more detailed explanation on the function of this button is described above.

d. Current FD - PFK 24

Selection of the current flight deck will cause the same job sequence as that described in detail in section B.1.b.

e. Current HD - PFK 25

Selection of the current hangar deck will cause the same job sequence as that described in section B.1.c.

f. Switch Station - PFK 31

Selection of this PFK button returns the operator to the initial station selection page in the same manner described in section B.1.1.

2. Current Flight Deck - PFK 2

Selection of this PFK button simulates the repeater-only option at this station and displays the current flight deck. Return is the same as described in section B.3.

3. Current Hangar Deck - PFK 2

Selection of this PFK button simulates the repeater-only option at this station and displays the current hangar deck. Return is the same as that described in section B.4.

4. Switch Station - PFK 31

Selection of this function causes the same job sequence as that described in section B.6.

The display is intended to be self explanatory and the prompt messages are intended to allow an operator to perform some tasks at the display, perform another task in another place, and return to the display and be able to resume changing the information.

F. CARRIER AIRGROUP COMMANDER'S STATION

Having selected the Carrier Airgroup Commander's station, the operator will see a list of the views available at this station. The views available at this station are current flight deck, current hangar deck and squadron

maintenance. The operator also has the option of switching stations at this time. Selection of the SWITCH STATION PFK button will erase the display and then display the initial station selection view page.

Selection of any PFK button corresponding to an allowed view at this station will display the desired view and a menu on the left hand side of the display. This menu has a list of the views available at this station. The station functions as a repeater-only display and the use of PFK buttons is functionally equivalent to the television channel selector previously described in the thesis. The procedure to switch views involves selection on an appropriate PFK button corresponding to a desired view.

G. SQUADRON READY ROOM STATION

If the operator has selected the PFK button on the initial station selection page corresponding to this station, a list of the squadrons currently onboard appears. Select the PFK button corresponding to the desired squadron. The operator will then see a list of the views available at this station. The views available are the current flight deck, the current hangar deck, maintenance status and the spot plan. In addition, the operator may elect to switch station at this time.

Selection by the operator of the PFK button corresponding to the current flight deck, the current hangar

deck, the squadron maintenance status or the spot plan will erase the display and then display the requested view. In addition, the prompt message "<CR> FOR NEXT VIEW" will appear in the lower middle of the display. When the operator has finished viewing the display, pressing any PFK button will cause the current display to be erased, and the list of views available at this station to be displayed.

If the operator selects a PFK button without a corresponding view at this station, a flashing "INVALID SELECTION" message will appear on the lower middle portion of the display. The operator is then allowed to select a PFK button corresponding to a view available at this station.

If the operator selects the SWITCH STATION PFK button, the current display will be erased, and the operator will be returned to the initial station selection page.

H. DATA BASE MODIFICATION

The data base is stored in five separate files when the simulation program is not running. The five files are the acho.r, maint.r, scr.r,spot.r, and aircraft.r files. The data base setup routines open these files during initialiation and read the data into the data base arrays for use by the simulation program.

In order to add or delete aircraft, the acho.r, maint.r, scr.r and spot.r files must be modified. The four files are

organized by squadron. In the maint.r file, the squadron blocks are headed by the squadron name. The next line has the number of aircraft in the squadron. The remaining lines in the block have maintenance information on each aircraft, one aircraft per line. The other three files are also organized by squadron blocks, but do not have the squadron name line. Modification of any one of the files requires an operator to modify all four files for the same aircraft.

Addition of an aircraft requires the operator to change the number of aircraft in the squadron block to the correct number and then enter the data for the aircraft. (See Figure 11). The procedure described below will enter a stub for the aircraft, which can then be interactively modified during program execution. The operator enters the aircraft side number, and then enters zeros in all maintenance fields except the status field. The status field should have a one. This procedure enters an up, airborne aircraft in the maintenance data base.

The acho.r and scr.r files contain the actual aircraft location and the location of the aircraft in the scratchpad data base. These files do not have the squadron name line. The key field is the side number field. The operator changes the number of aircraft in the squadron, then enters the new aircraft side number. The remaining fields are assigned zero, except for the type field. The type field entry will correspond to the type aircraft code. The procedure enters an up, airborne aircraft in the aircraft

location and scratchpad data bases.

The spot.r file does not have the aircraft side number, but is also organized by squadrons. The operator first changes the number of aircraft and then inserts the information on the line in the squadron block corresponding to aircraft entry in the other three fields. To enter an aircraft stub in the spot data base, the operator enters zeros in all fields except the Y-coordinate field. The operator should enter 2000 in this field. This procedure enters the aircraft stub in the spot data base, but the aircraft will not be visible on the spot plan until the ACHO actually interactively assigns it to the spot plan.

Deletion of an aircraft involves changing the number of aircraft in the squadron block in all four files and then removing the aircraft information from the files.

To insert a new squadron, the operator inserts the new squadron block based on that squadron's aircraft side numbers. The squadron name is inserted on one line, the number of aircraft in the squadron is inserted on the next line, and the aircraft information on each aircraft is inserted in the same manner described above, one aircraft per line. The corresponding squadron block is inserted in the other three files, using the same procedures described above. Deletion of a squadron is the inverse of the above procedure.

I. PROGRAM INITIALIZATION

When the simulation is executed, the operator must first enter the ACHO station scratchpad and select SCRATCH TO CURR. This procedure must be followed in order to restore the data base completely. The procedure initializes the various aircraft list arrays used by the ACHO scratchpad and spot plan routines.

The operator is provided with two options for program execution. One option will initilize the data base to the information stored prior to the last simulation. The other option will initilize the data base to the information stored at end of the last simulation. To execute the first option, the operator uses the shell command aihs.rerun. Aihs.run allows the operator to execute the second option.

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